Advanced Cell Biology. Lecture 5

Alexey Shipunov

Minot State University

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Outline

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Questions and answers

Fatty acids and lipids

- Membrane lipids
- Signal lipids: sterols and others
- Lipid vitamins

Amino acids

- Structure and classification

Previous final question: the answer

What is the difference between α- and β- glucose?

Previous final question: the answer

What is the difference between α- and β- glucose?

- α down (axial position), β up (equatorial position)

Fatty acids and lipids

Membrane lipids

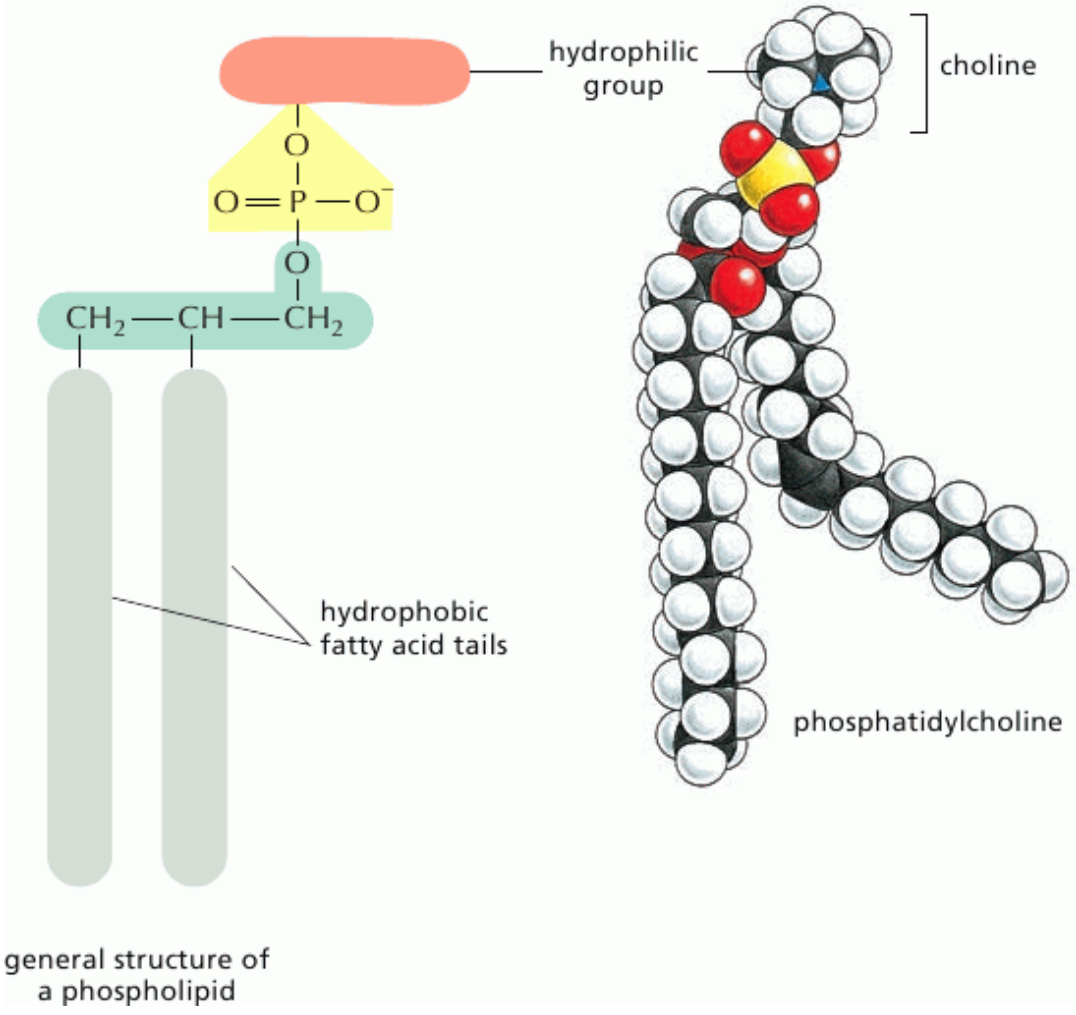
Membrane lipids

- Membrane lipids are structural units of membrane double layer
- Their chemical structure is similar to triacylglyceroles (fats) but one of fatty acids is replaced with other molecule

Phospholipids

- Phospholipids are esters of glycerol (or sphingoside), fatty acids and phosphorous acid
- Head + two tails structure
- Glycerol + phosphate head is hydrophilic whereas fatty acid tail is hydrophobic

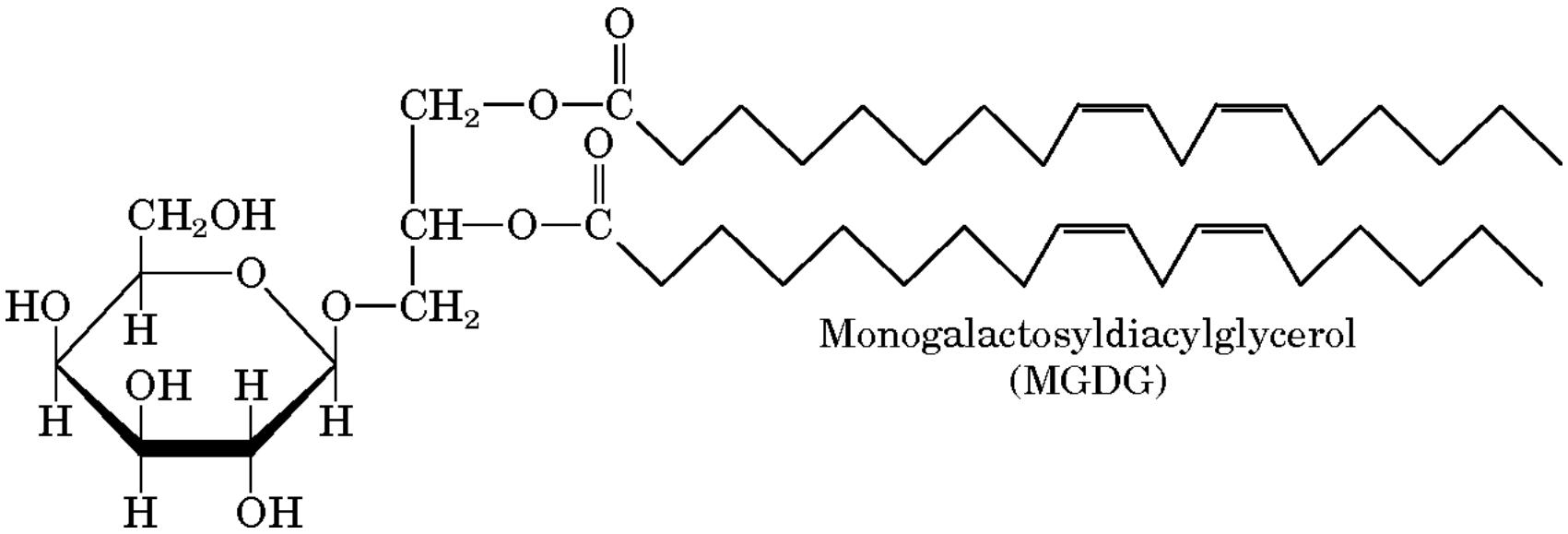
Phospholipids



Glycolipids

- Glycolipids have two hydrocarbon tails and sugar head
- Often occur in plant cells, especially in chloroplasts

Glycolipids

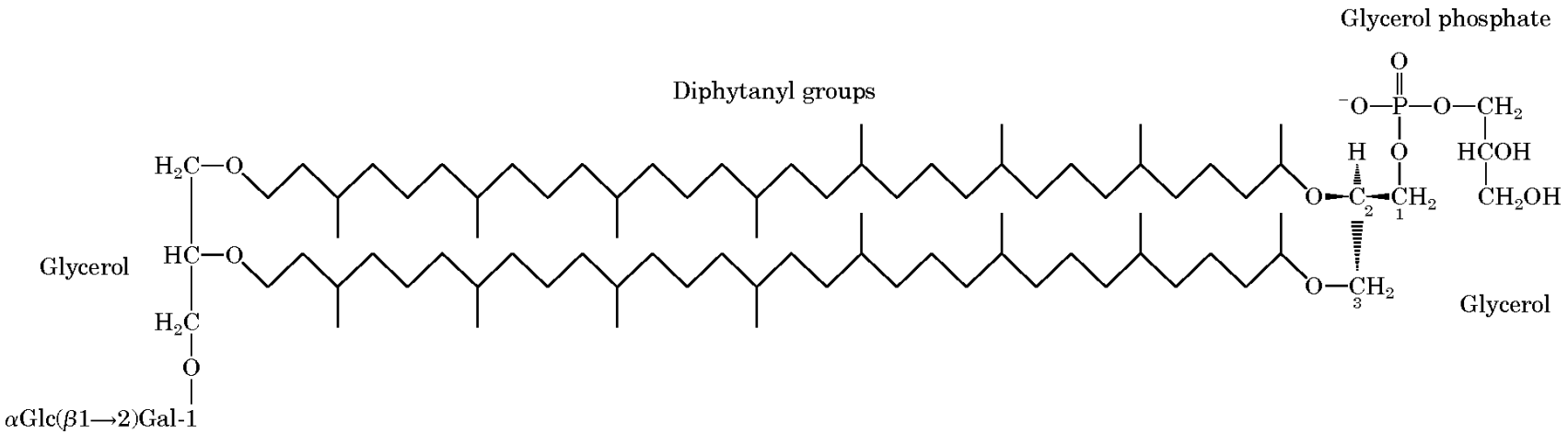


Monogalactosyldiacylglycerol
(MGDG)

Archaea membrane lipids

- Archaea (or archebacteria) have highly specific biochemistry
- Their membranes contain glycerol dialkyl glycerol tetraethers (GDGTs) which are double esters (have glycerol from both ends) and span the whole membrane
- These membranes are much more stable to high temperatures and low pH

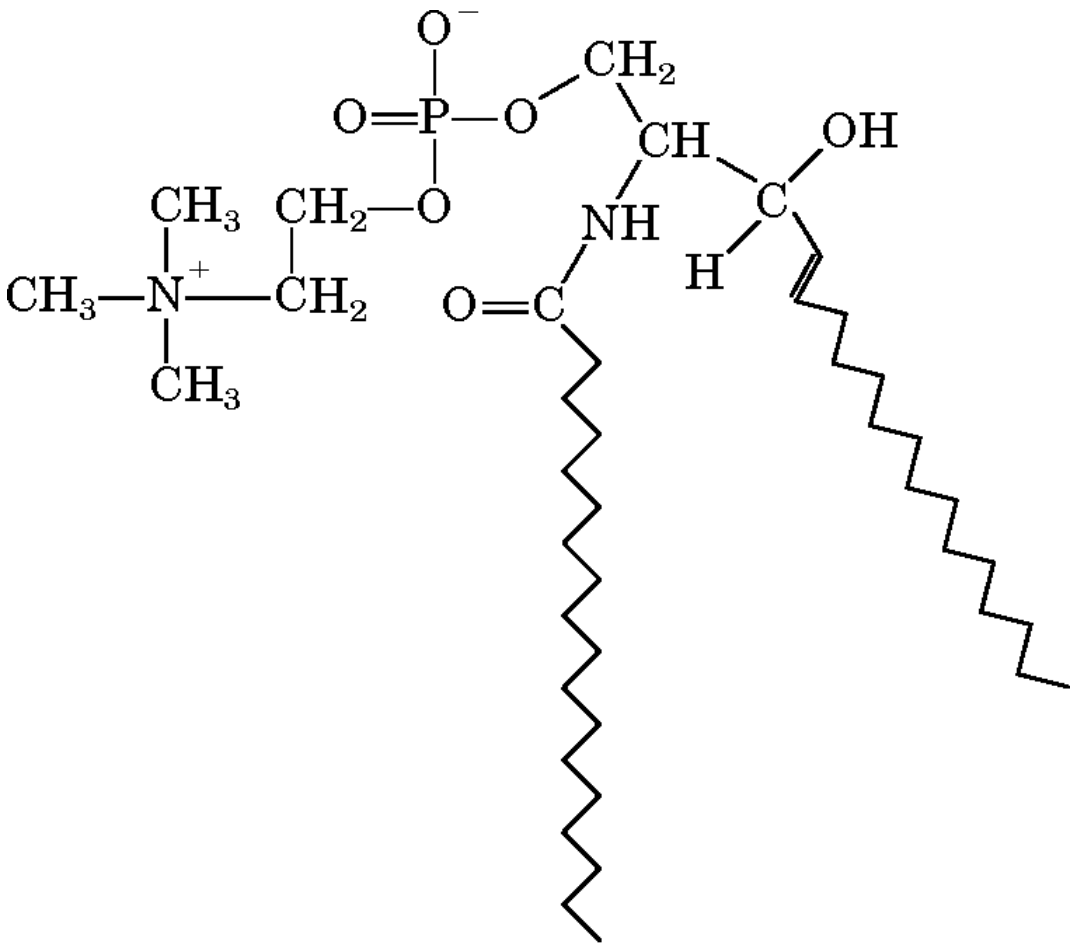
Glycerol dialkyl glycerol tetraethers (GDGTs)



Sphingolipids

- Sphingolipids are composed of one *sphingosine* (long chain amino-alcohol), one polar head and one fatty acid
- Again, head + two tails structure
- Sphingolipids in the membrane are important sites of biological recognition; nervous cells are especially rich of sphingolipids

Sphingomyelin

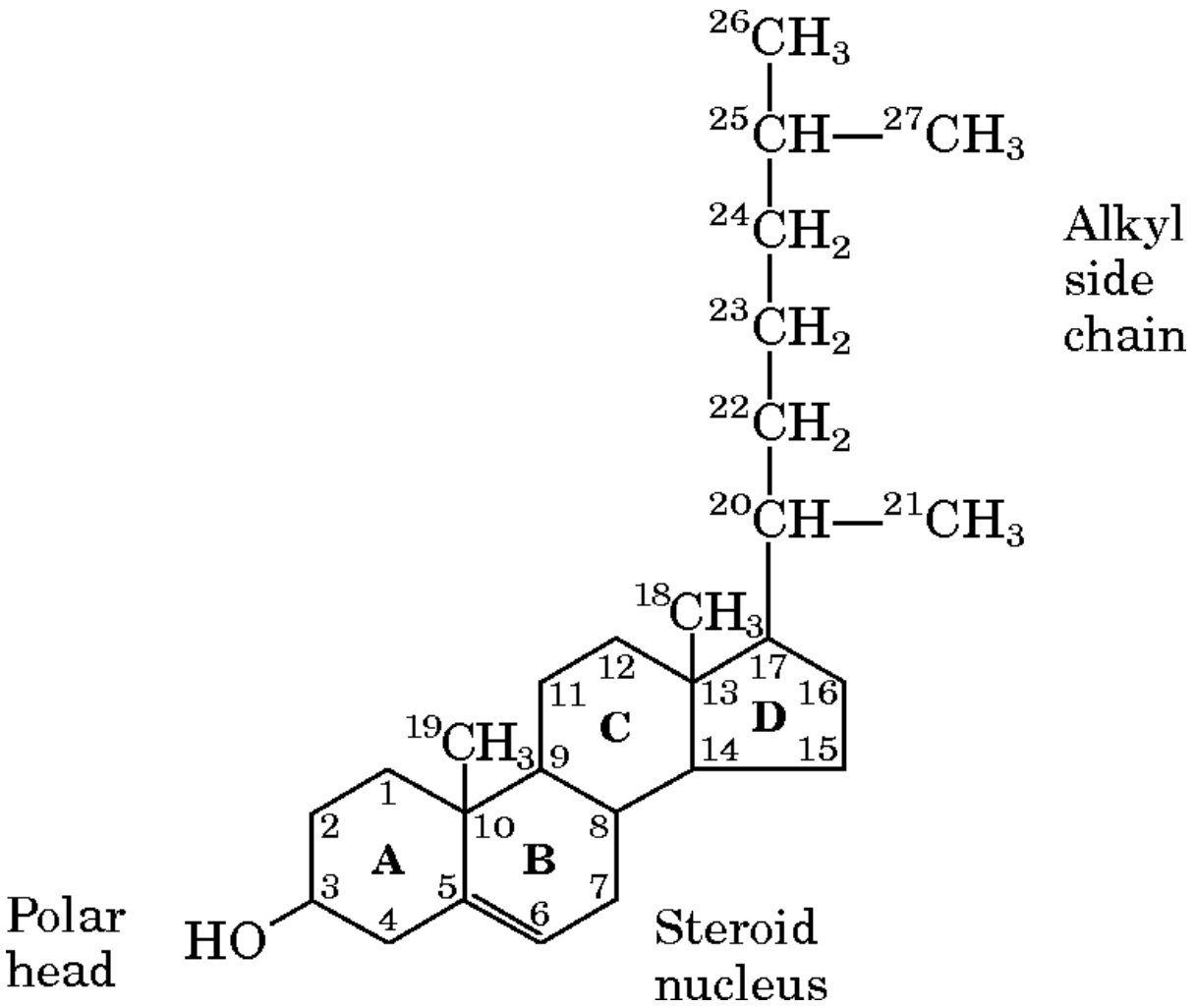


Sphingomyelin

Cholesterol

- Cholesterol is a *sterol*: molecule with four fused carbon rings
- One of main components of membrane, and also precursor to steroid hormones and other molecules
- Coronary disease is directly connected with cholesterol metabolism

Cholesterol



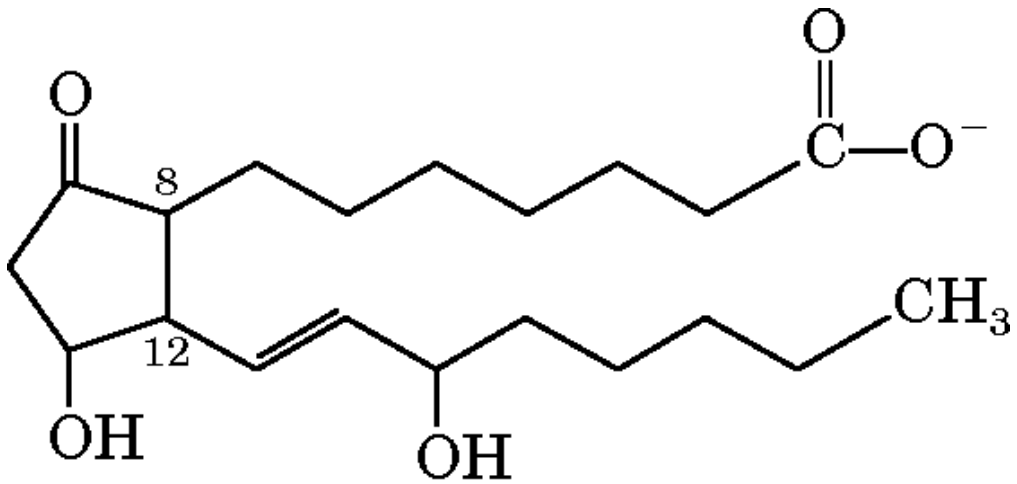
Fatty acids and lipids

Signal lipids: sterols and others

Eicosanoids: derivatives of fatty acids

- *Eicosanoids* are hormones—biochemical signals
- They are structurally similar to membrane lipids
- Some of them, e.g., *prostaglandins*, play important physiological roles

Prostaglandin, one of eicosanoids

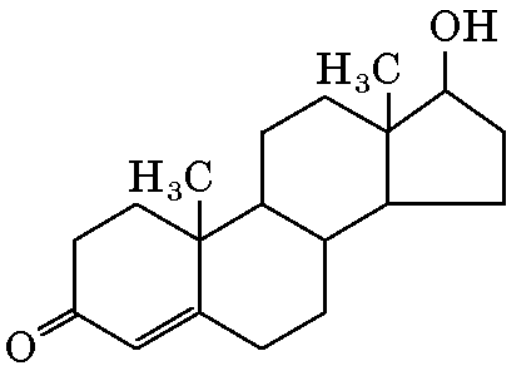


Prostaglandin E_1
(PGE_1)

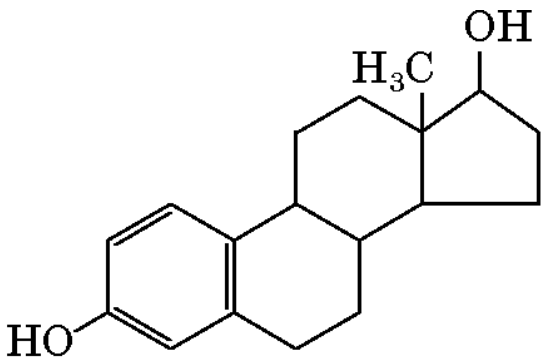
Steroids

- *Steroids* are derivates of *sterols* (mostly cholesterol)
- Occur both in plants and animals
- Have high specificity to receptors and therefore are producing in small quantities
- In vertebrates, play a role of sex hormones

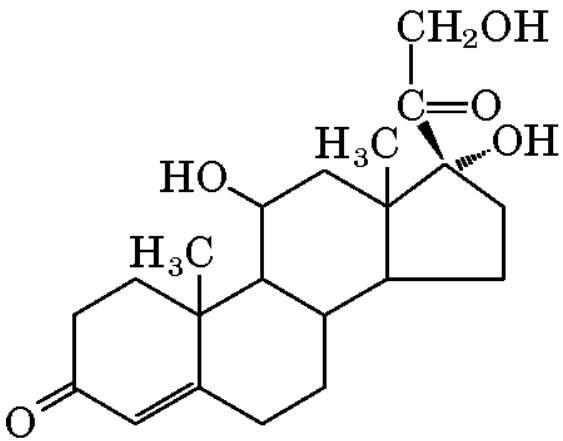
Steroids



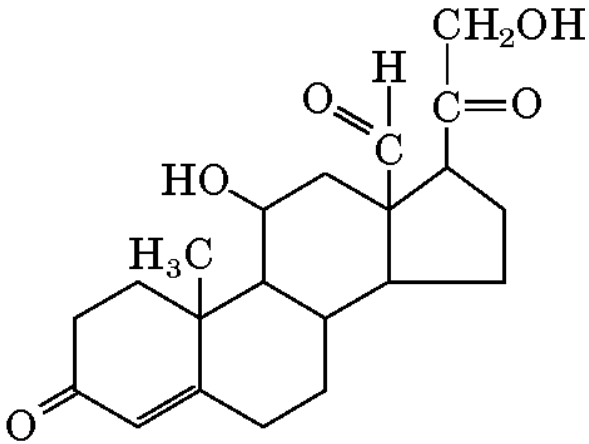
Testosterone



Estradiol



Cortisol



Aldosterone

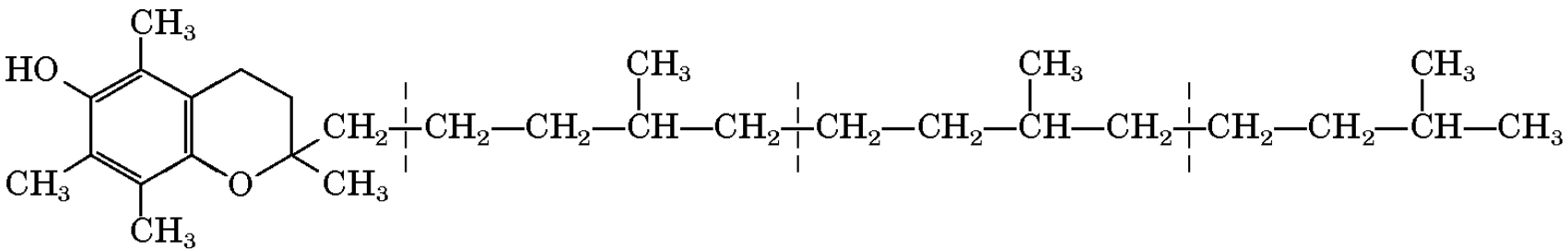
Fatty acids and lipids

Lipid vitamins

Lipid vitamins

- Vitamin **D** (close to sterols) transforms into hormone regulating calcium uptake
- Vitamin **A** (retinol) transforms into retinal which is a main light response pigment of eye
- Vitamin **E** (tokoferol) assists in numerous biosynthetic processes

Vitamin E, tokoferol



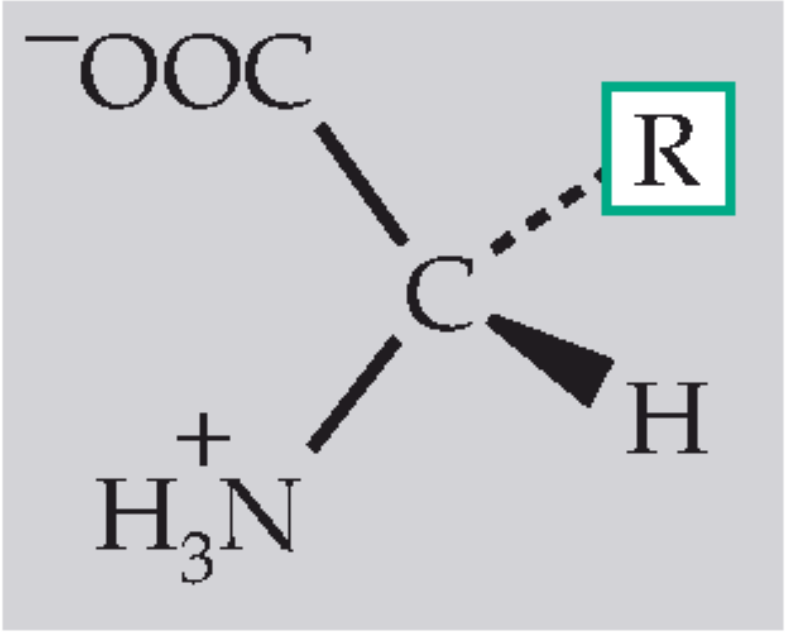
Amino acids

Structure and classification

Structure

- Typical formula is $H_2NCHRCOOH$ where R is organic radical
- Amino group is normally attached to the first carbon in the chain: α-aminoacids

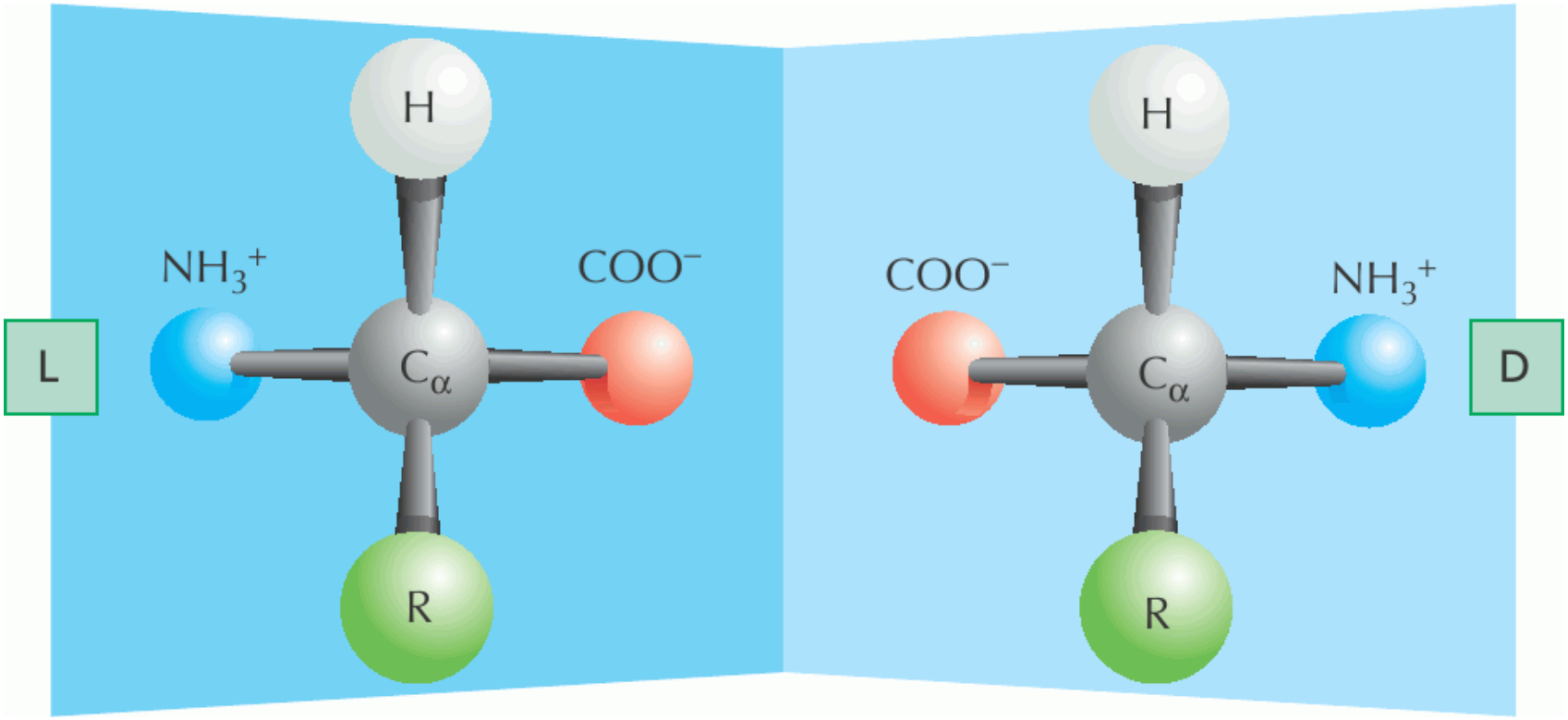
Amino acid



Isomerism

- α-carbon is an asymmetric atom
- Therefore, two optical isomers are possible
- However, in nature only L-isomers occur

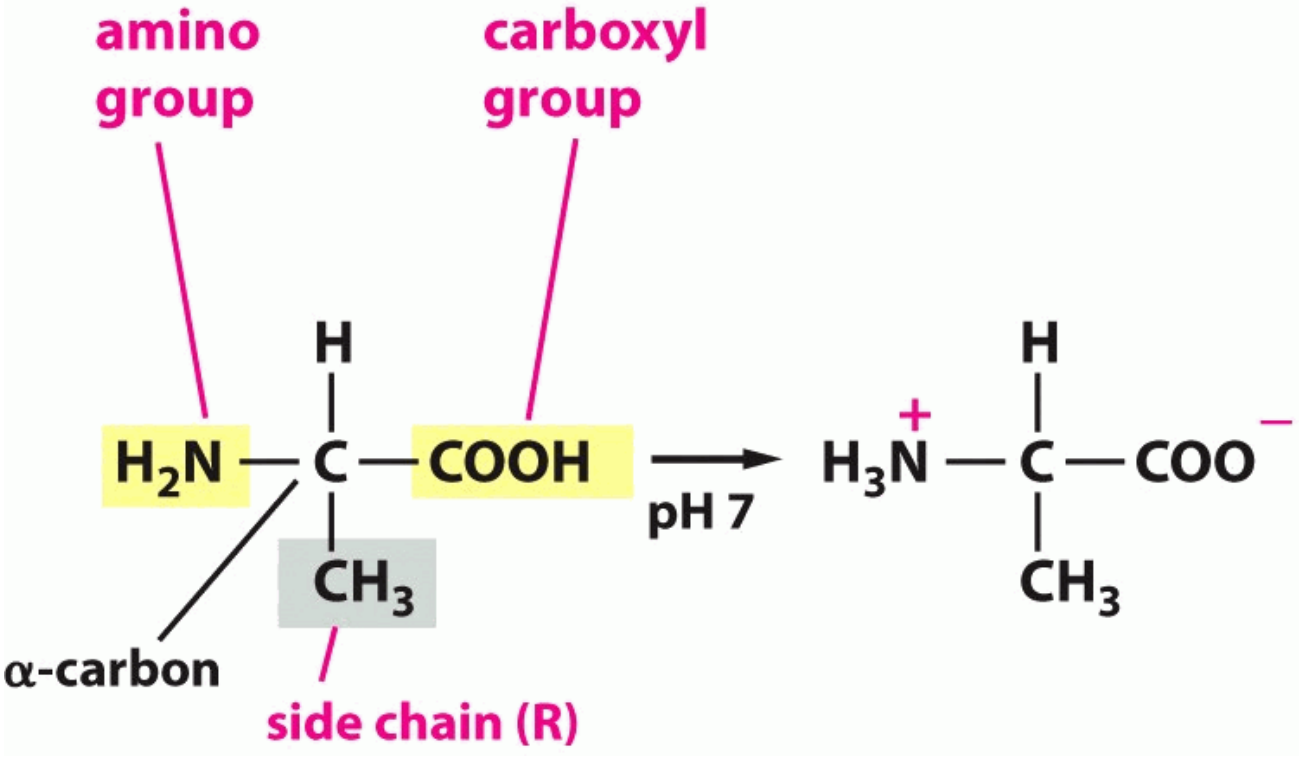
L- and D- isomers



Zwitterions

- If radical is neutral, amino acid could behave as both acid and base
- Many amino acids are present in water solution as **zwitterions**: polar structures similar to both acids and bases

Zwitterion


amino group
carboxyl group
H
H_2N — C — COOH
CH_3
α-carbon
side chain (R)
pH 7
H_3N^+ — C — COO^-
H
CH_3

Diversity: 20 standard and 2 additional

- Standard amino acids are structural units of proteins; they are encoded via DNA triplets
- There are exactly 20 standard amino acids
- In addition, there are two amino acids (selenocysteine and pyrrolysine) which may be coded in deviated genetic codes of some organisms

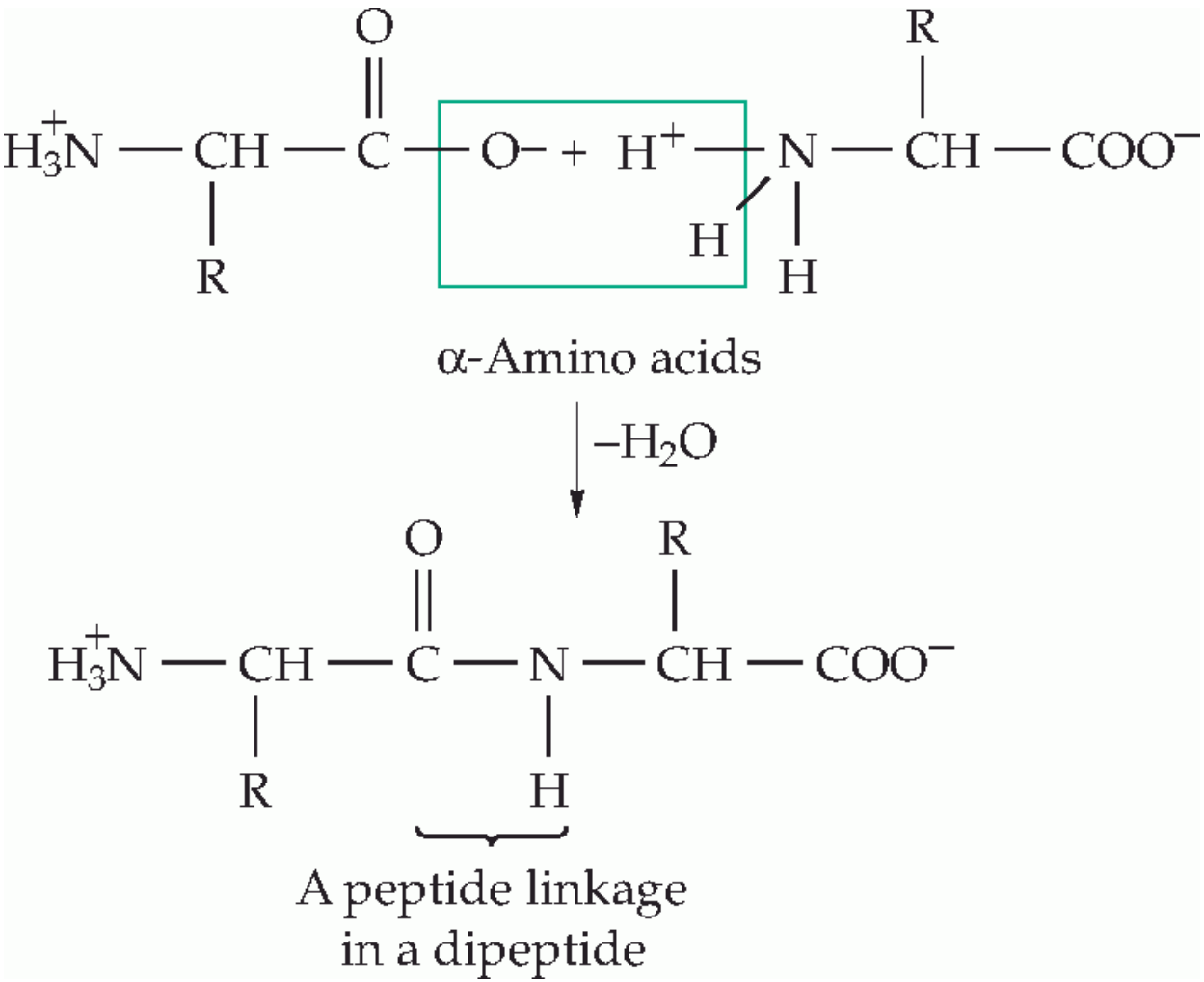
Essential and non-essential

- Essential amino acids could not be synthesized in human body
- Non-essential amino acids are derivatives of essential
- In all, there are eight essential amino acids:
  1. Isoleucine
  2. Leucine
  3. Lysine
  4. Methionine
  5. Phenylalanine
  6. Threonine
  7. Tryptophan
  8. Valine

Peptide bonds

- Amino acids may group together in peptides via peptide bonds
- This is **reaction of condensation**, it results also in one water molecule

Reaction of condensation



Roles

- Most important: components of peptides and proteins
- Many are intermediate stages of different biosynthetic processes, e.g.:
  - *Tryptophan* is a precursor of the neurotransmitter *serotonin*
  - *Aspartate*, *glycine* and *glutamine* are precursors of nucleotides

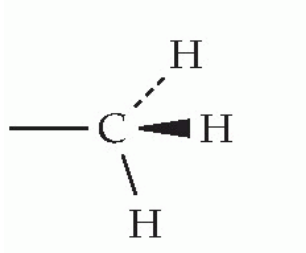
Amino acid diversity by groups: glycine

- Simplest amino acid
- “R” is simply H in case of glycine

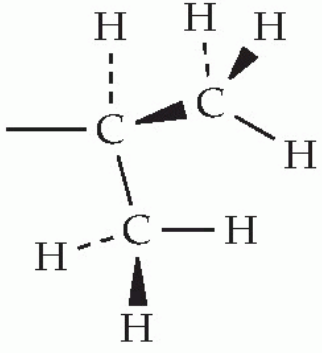
Alkyls

- Have hydrocarbon groups as radicals
- Hydrophobic and therefore involving in protein shaping

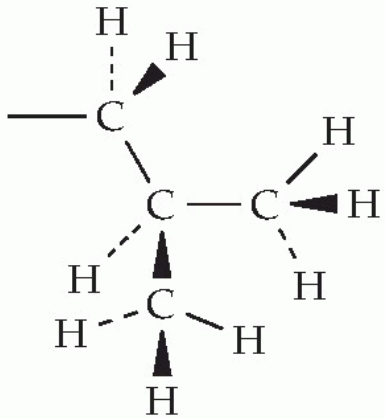
Alkyl amino acids



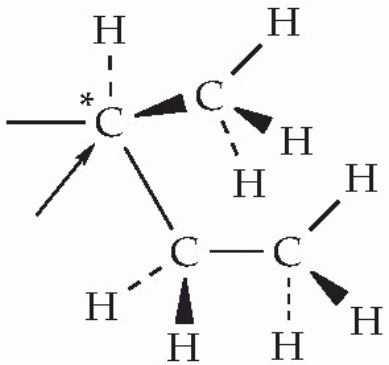
Alanine (Ala, A)



Valine (Val, V)



Leucine (Leu, L)

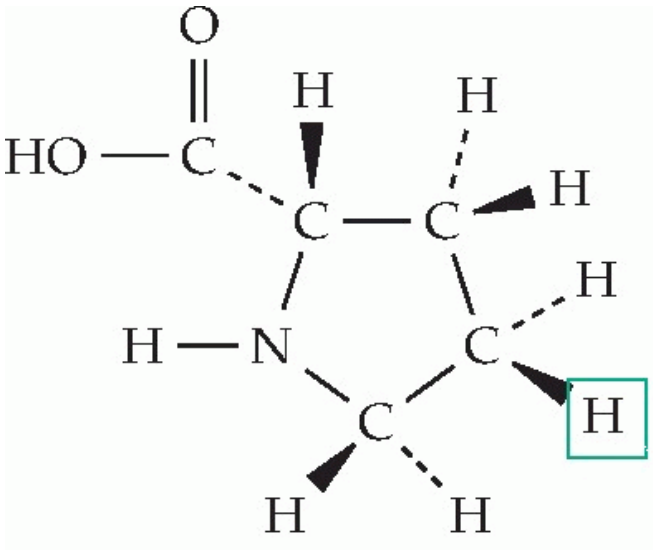


Isoleucine (Ile, I)

Imines

- Not an amino acids in a strict sense because there are no α-carbon
- Molecule is rigid and influence protein folding

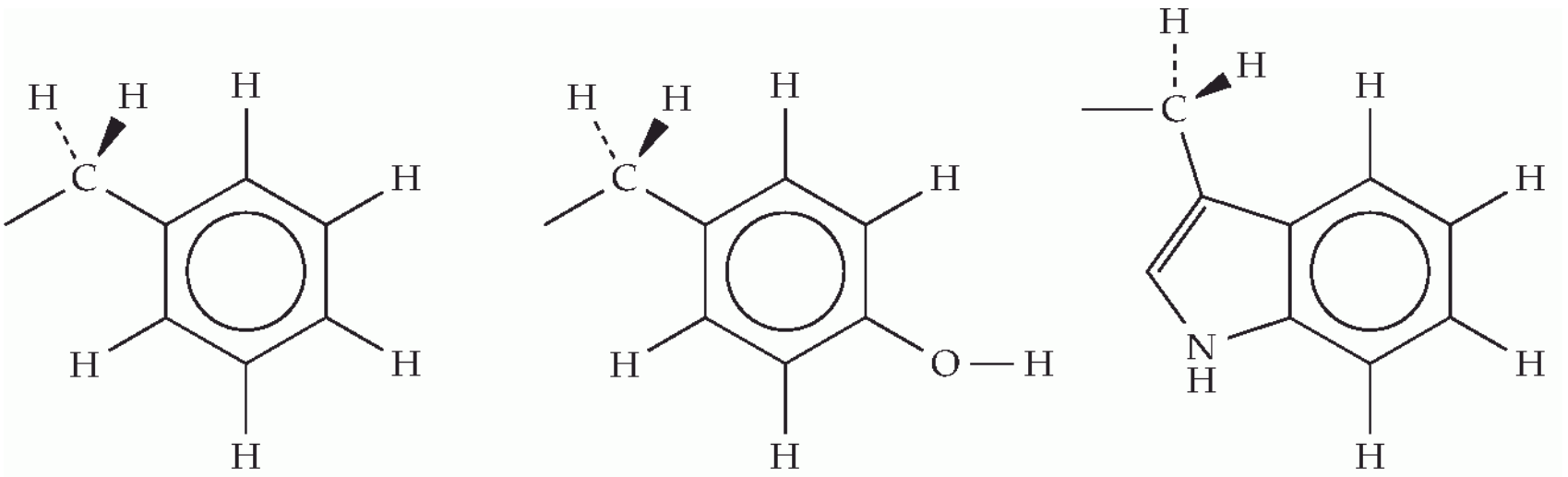
Imines


O
HO
C
H
H
C
C
H
H
H
N
C
H
C
H
H
H replaced by —OH in hydroxyproline (Hyp) which occurs in collagen
Proline (Pro, P)

Aromatic

- Contain benzene groups
- May form hydrophobic bonds

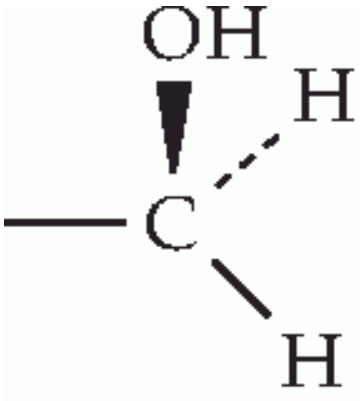
Aromatic amino acids



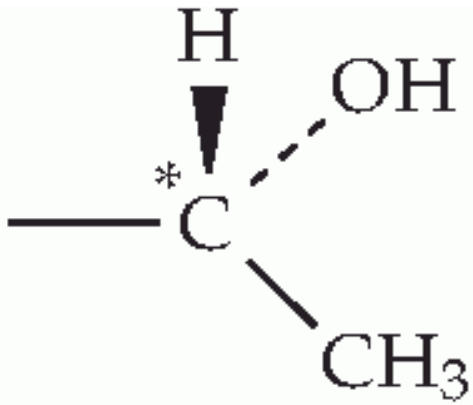
Alcohols

- –OH group is very weakly acidic
- May form active centers of some enzyme proteins

Alcohol amino acids



Serine
(Ser, S)



Threonine
(Thr, T)

Final question (2 points)

Final question (2 points)

Which role in the cell lipids do NOT play?

Summary

- Lipids are extremely diverse; the only character uniting them is their hydrophobic behavior
- There are 20 (+2) standard amino acids classifying in 9 groups

For Further Reading

A. Shipunov.
Advanced Cell Biology [Electronic resource].
2011—onwards.
Mode of access: `http://ashipunov.info/shipunov/school/biol_250`

B. Alberts et al.
Essential Cell Biology. 3rd edition.
Garland Science, 2009.
Chapter 2: : Molecules in cells, Panels 2–5.